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IN THE MATTER OF  
International Patent Application No.  
PCT/EP97/05221  
In the Name of Braun Aktiengesellschaft

DECLARATION

I, Birgit Hubatsch, of Elisabethenstr. 33a, D-64390 Erzhausen, Federal Republic of Germany, do hereby declare as follows:

1. That I am well acquainted with both the English and German languages, and
2. That the attached document is a true and correct translation made by me to the best of my knowledge and belief of:

The specification accompanying the International Patent Application No. PCT/EP97/05221.

Dated this 17th day of February 1999

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HANS et al.  
GERMAN DE 196 40 853  
is priority case  
of this



*Birgit Hubatsch*

Birgit Hubatsch  
Sworn Translator

**Bristle for a Toothbrush**

This invention relates to a bristle for a toothbrush, in particular for an electric toothbrush, which is made of plastic and includes several filaments joined together.

5 A bristle of this type is known from German Utility Model No. 19 97 717. This specification describes a toothbrush which has a plurality of bristles, each bristle being comprised of several filaments in an approximately parallel arrangement and welded thermally to one another. In this manner, the cleaning  
10 area formed by the free ends of the bristles is enlarged and hence the cleaning effect of the toothbrush increased. On the other hand, cavities involving the risk of being populated by bacteria or other germs are formed between the filaments.

From DE-PS 906444 there is known a method of manufacturing  
15 man-made bristles which are comprised of a plurality of individual filaments. These individual filaments are adhesively bonded to each other after exiting the spinning nozzles, with the bonding process being interrupted at intervals. Following fabrication of the adhesive bond, the bristle is cut to individual  
20 bristles in the non-bonded areas, with the individual bristle being fanned out at its tip. This method is rather elaborate, requiring the application of an adhesive to the filaments. In addition, interrupting the bonding process continuously at predetermined intervals is problematic.

25 From DE-AS 1 222 888 a brush is known having radially outwardly directed bristles attached to a hub. Each of the bristles has in its center a rigid core having at least one fiber of a vibration-damping material bonded thereto and helically wound around it in such fashion that only part of the  
30 core's surface is surrounded by the fiber.

It is an object of the present invention to further develop a bristle for a toothbrush of the type initially referred to, such that a high cleaning effect is guaranteed but cavities are eliminated.

5        This object is accomplished by the invention in that the filaments are wound or braided and chemically welded together as a result of the action of chemical agents.

10        The filaments lie in close proximity to each other as the result of winding or braiding the filaments, or generally as the result of stranding the filaments. The surface area of the filaments is then subjected to partial dissolving by means of chemical agents. In this manner, the filaments merge completely together and any cavities still remaining in the center of the wound or braided bristle are closed. This process can be sup-  
15        ported by any existing or selectively variable tensile stress acting on the filaments. Altogether a cavity-free bristle is thus produced, offering bacteria or other germs no possibility of infiltration.

20        By using several filaments, however, the surface area of the toothbrush active in cleaning the teeth is at the same time enlarged, thereby improving the tooth cleaning action. Further, the surface area of the bristles is structured as a result of the winding or braiding operation, a fact that may be put to effective use during the cleaning of teeth. Both aspects are  
25        advantageous particularly with regard to the removal of plaque from the tooth surface.

30        In an advantageous embodiment of the bristle of the present invention, the free end of the bristle has a fanned arrangement. This fanned arrangement can be achieved by breaking open the joints of the individual filaments at the free end of the bristle. In this manner, individual thin tips are formed at the free end of the bristle, their number and diameter depending on

the number and diameter of filaments in the bristle. These thin tips are able to penetrate the interproximal spaces far more easily and deeply, thereby improving the removal of plaque at these locations and thus improving the cleaning of teeth as a whole. Further, the surface area active in cleaning the teeth is further enlarged by the fanned arrangement, which in itself improves the cleaning of teeth.

In a further advantageous embodiment of the bristle of the present invention, the filaments of the bristle have different diameters. In this way it is possible to vary the mechanical properties, for example, rigidity or fatigue or resilience, of the individual bristles and hence of the toothbrush as a whole. Further, by appropriately selecting the diameters of the filaments, it is possible to also vary the winding or braiding of the individual bristles and hence the surface structure of the bristles. Both have a direct effect on the cleaning action and in particular on the cleaning comfort of the toothbrush.

In a preferred feature of the embodiment referred to, provision is made for one approximately central filament of preferably greater rigidity, which is surrounded by filaments of preferably less rigidity. The central filament serves preferably to stabilize the bristle, while the filaments surrounding this central filament are preferably intended to achieve a high cleaning effect and high cleaning comfort.

In an advantageous further configuration of the bristle of the present invention, the winding or braiding of the bristle follows a periodic pattern. This has advantages with regard to the manufacture of the bristle, in addition to resulting in a visually uniform appearance of the bristle and hence of the toothbrush as well.

The following values have proven to be especially suitable in particular for an electric toothbrush: three or four

filaments per bristle are used, the diameter of the individual filaments lies between 0.0762 mm and 0.127 mm, approximately, and the winding or braiding of a bristle is repeated after every 1.0 mm to 3.0 mm, approximately.

5        According to a further advantageous embodiment of the present invention, the filaments are chemically welded together so firmly that in the area of the fanning a tear-growth resistance or peeling force of the filaments of between 0.1 N and up to 0.15 N, preferably of 0.125 N results. This ensures that the  
10        bristles of the present invention fan out at their ends a small amount following the conventional, in particular mechanical rounding of an end section, for example, after the bristles are attached in a bristle carrier. Yet on the other hand, the tear-growth resistance is so high that further fanning out of the  
15        bristle into individual filaments is essentially prevented during normal use of the bristles, for example, as bristles of a toothbrush.

         It has proven to be a particular advantage that amounts of 10% up to 50%, preferably 20% to 35%, of the cross-sectional  
20        area of the filaments are partially dissolved as a result of the action of the chemical agents. This reliably prevents the formation of cavities between the filaments. Furthermore, with such a degree of partial dissolution each of the filaments yet has an inner strength adequate to enable the chemical welding  
25        together of the filaments to form a bristle to be performed readily and continuously.

         In cases in which filaments of a crystalline or part-crystalline material as, for example, polyamide, are employed, an outer envelope of the bristle has an amorphous structure  
30        following chemical welding of the filaments, whilst an inner core has an essentially crystalline structure.

In the center of the inner core there may then again be present an amorphous structure of the filament or bristle material.

In general the area of cross-section having the amorphous structure may amount to about 10% up to 50%, in particular 20% up to 30% of the total area of cross-section of the bristle. Correspondingly, the balance of the cross-sectional area has an essentially crystalline structure.

In an advantageous method of manufacturing a bristle according to the present invention, the filaments are wound or braided essentially without torsional stress and chemically welded together by the action of a solvent. Hence the winding or braiding operation is followed by joining of the filaments as a result of chemical agents. In this manner, a durable joint between the individual filaments is accomplished, while the mechanical properties of the filaments are substantially retained. The result is a composite filament structure which forms the bristle. Further, the partial dissolving of the filaments in a solvent ensures that any cavities, which may still exist, are reliably closed. Still further, the fixing operation referred to represents a simple and highly controllable method of processing the wound or braided filaments and joining them together to form a bristle.

In an advantageous further configuration of the method of the present invention, the filaments are wetted with a solvent for a period of between 5 s and 50 s, approximately, preferably for between 20 s and 30 s, approximately, where coated filaments are involved, for example. Highly concentrated formic acid has proven to be a particularly appropriate solvent for filaments made of polyamide.

An advantageous feature of the method of the present invention consists in fanning out the free end of the bristle by a

mechanical process. The resulting thin tips are able to penetrate the interproximal spaces far more easily and deeply, thus improving the removal of plaque at these locations and hence the cleaning of teeth as a whole.

5        According to another highly advantageous further configuration of the present invention, during the process of chemical welding together the filaments are exposed to tensile stress of between 6 MPa and up to 20 MPa, approximately, preferably 13 MPa. It is thereby ensured that the filaments which are wound  
10 or braided essentially without torsional stress are in relative contact with a sufficient force acting radially inwardly during chemical welding, with this radially inwardly acting force being generated by means of the tensile stress acting on the filaments.

15        In a particularly advantageous further configuration of the invention, the bristles of the present invention are used in the inner field of a preferably electrically powered round-head toothbrush.

20        Further features, advantages and application possibilities of the present invention will become apparent from the subsequent description of embodiments illustrated in more detail in the accompanying drawings. It will be understood that any single feature and any combination of single features described and/or represented by illustration form the subject-matter of  
25 the present invention, irrespective of their summary in the claims and their back reference. In the drawings,

FIGS. 1a to 1c are a schematic view and two cross-sectional views of a toothbrush bristle constructed in accordance with the present invention, illustrating a first embodiment thereof;

FIGS. 2a and 2b are a schematic view and a cross-sectional view of a toothbrush bristle constructed in accordance with the present invention, illustrating a second embodiment thereof;

FIGS. 3a and 3b are a schematic view and a cross-sectional view of a toothbrush bristle constructed in accordance with the present invention, illustrating a third embodiment thereof;

FIG. 4 is a schematic view of the free end of the bristle of FIG. 3, illustrating a fanned arrangement; and

FIG. 5 is a cross-sectional view, in detail and on an enlarged scale, of a bristle of FIG. 3b.

FIGS. 1a to 1c show a bristle 1 which is comprised of three filaments 2, 3, 4. The filaments 2, 3, 4 are fabricated from the same plastic and have all the same diameter. The filaments 2, 3, 4 are braided, as becomes also apparent from the cross-sections of FIGS. 1b and 1c. The braiding is executed uniformly, which means that the braid and hence the surface structure of the bristle 1 is repeated at periodic intervals. This repeat is identified by reference numeral 5 in FIG. 1a.

FIGS. 2a and 2b show a bristle 6 which is comprised of four filaments 7, 8, 9, 10. Filament 7 is arranged centrally and is surrounded by the other filaments 8, 9, 10. Filament 7 is larger in diameter than filaments 8, 9, 10. Filaments 7, 8, 9, 10 are all made of plastic, with filaments 8, 9, 10 being made of the same plastic material, while the central filament 7 may be made of a different plastic material. Preferably, the central filament 7 has a high level of rigidity while the surrounding filaments 8, 9, 10 are less rigid. The different degrees of rigidity may be due to the filaments having different diameters and/or being fabricated from different plastics, for example, softer or harder plastics. The central filament 7 is enwound by the other filaments 8, 9, 10. The winding is



executed uniformly, causing the winding and hence the surface structure of the bristle 6 to be repeated at periodic intervals. This repeat is identified by reference numeral 11 in FIG. 2a.

FIGS. 3a and 3b show a bristle 12 which is comprised of three filaments 13, 14, 15. The filaments 13, 14, 15 are made of the same plastic and have all the same diameter. The filaments 13, 14, 15 are wound. The winding is executed uniformly, causing the winding and hence the surface structure of the bristle 12 to be repeated at periodic intervals. This repeat is identified by reference numeral 16 in FIG. 3a.

The filaments designated 2, 3, 4, 7, 8, 9, 10, 13, 14, 15 of the bristles 1, 6, 12 of FIGS. 1a to 1c, 2a and 2b as well as 3a and 3b may be made of polyamide, polyester or polypropylene. The diameter of the identified filaments may amount to between 0.0762 mm (3 mils) and 0.127 mm (5 mils), approximately. The repeat 5, 11, 16 of the braiding or winding of the filaments referred to may have a value of between 1.0 mm and 3.0 mm, approximately. As will be explained in the following, the individual filaments 2, 3, 4, 7, 8, 9, 10, 13, 14, 15 of the bristles 1, 6, 12 are joined securely together.

FIG. 4 shows a free end 17 of the bristle 12 of FIGS. 3a and 3b. The free end 17 displays a fanned arrangement 18. This means that the free ends 19, 20, 21 of the filaments 13, 14, 15, respectively, are not joined together but project from the free end 17 of the bristle 12 as individual tips. The length of the fanned arrangement 18 is selected so that the projecting tips are inclined to penetrate a user's interproximal spaces.

The described fanned arrangement of the free end of the bristle may also exist accordingly on the bristles of FIGS. 1a to 1c and/or FIGS. 2a and 2b.

To manufacture the bristles 1, 6, 12, the filaments 2, 3, 4, 7, 8, 9, 10, 13, 14, 15 are braided or wound or generally stranded. It is possible to perform the winding or braiding operation with prior stretched filaments 2, 3, 4, 7, 8, 9, 10, 13, 14, 15, which already have the required mechanical properties.

The braided or wound filaments 2, 3, 4, 7, 8, 9, 10, 13, 14, 15 are then dipped in a solvent where they are fixed by partial dissolving. The dwell time in the solvent amounts to a period of between 5 s and 50 s, approximately. Phenol, M-cresol or formic acid may be used as solvents for filaments made of polyamide, for example. With coated filaments a period of between 20 s and 30 s, approximately, has proven to be advantageous when using highly concentrated formic acid. By wetting the filaments 2, 3, 4, 7, 8, 9, 10, 13, 14, 15 with the solvent, a firm bond is established between the joints of the filaments 2, 3, 4, 7, 8, 9, 10, 13, 14, 15.

The solvent is then neutralized with water or other suitable media, or the surplus solvent is removed. The filaments 2, 3, 4, 7, 8, 9, 10, 13, 14, 15 are then dried. The resultant bristle 1, 6, 12 can then be further processed in the known manner.

To produce the fanned arrangement 18 at the free end 17 of the bristle 12, this particular free end 17 is processed mechanically in a subsequent operation. This mechanical operation may involve, for example, a grinding operation or the like or some other impact operation performed on the free end 17. In whichever case the firm bond between the filaments 13, 14, 15 of the bristle 12 produced by the chemical fixing is broken up again in the area of the free end 17 of the bristle 12 by the mechanical operation. As a result, the free ends 19, 20, 21 of the filaments 13, 14, 15 are produced, with the length of the

free ends 19, 20, 21 and hence the length of the fanned arrangement 18 depending on the degree of the mechanical operation performed on the free end 17 of the bristle 12. The chemical fixing of the filaments 13, 14, 15 is executed in such a way as to  
5 enable the breaking up of the firm bond at the free end 17 of the bristle 12 on the one hand, but to prevent any breaking up of the firm bond between the filaments 13, 14, 15 by normal use of the bristle on the other hand.

As becomes apparent from FIG. 5, the chemical bonding of  
10 the filaments 13, 14, 15 made from part-crystalline material results in a particular cross-sectional structure of the bristle 12. An outer envelope 22 of the bristle 12 has an essentially amorphous structure which is attributable to the partial dissolving of the outer envelope of the individual filaments 13,  
15 14, 15 by the solvent. The inner core 23 of the bristle 12 possesses an essentially crystalline structure, said inner core 23 being formed substantially by the cores of the filaments 13, 14, 15 which were not subjected to the partial dissolving action. In the center 24 of the inner core there may be a small area of  
20 cross section with an amorphous structure. Filaments 13, 14, 15 welded together chemically in such manner possess an amorphous structure amounting to about 10% to 50%, in particular 20% to 30% of the total area of cross-section. Accordingly, about 90% to 50%, in particular 80% to 70%, of the cross-sectional area  
25 are essentially crystalline.

It proves to be particularly advantageous for the filaments to be in a condition nearly or essentially free from torsional stress following winding, braiding or stranding. This is ensured in that during the operations of braiding, winding or  
30 stranding each of the filaments 2, 3, 4; 7, 8, 9, 10; 13, 14, 15 is rotated about its own axis in a direction opposite to the direction of rotation necessary for stranding, braiding or winding, so that torsional stresses are substantially avoided.

Coiling of the filament composite prior to chemical welding and subsequent to stranding, braiding or winding is thus precluded. Evidence of this essentially torsion-free state can be furnished following welding by microtome cuts and analyzing the sections under polarized light. To ensure an optimal chemical welding together of the filaments 2, 3, 4; 7, 8, 9, 10; 13, 14, 15, fixing is performed under tensile stresses of between about 6 MPa and up to 20 MPa, preferably of about 13 MPa. Fixing is accomplished by the action of chemical agents which are however washed out leaving practically no residues or reaction products in the filament composite. The fixing period is selected such that amounts of between 10% and up to 50%, preferably between 20% and up to 35% of the cross-sectional area of the individual filament are partially dissolved. For filaments 2, 3, 4; 7, 8, 9, 10; 13, 14, 15 without surface coating the fixing period is in the range of between 5 sec and 20 sec or at around 10 sec. In cases in which filaments with a silicone coating are utilized, fixing periods of between 20 sec and 40 sec, preferably of between 25 sec and 30 sec, may be contemplated. Such a silicone coating enhances the sliding behavior of the filaments during manufacture. The bonding strength can be determined by measuring the peeling forces and the wear of the bristle 1, 6, 12. To ensure fanning out of the multifilament ends during the mechanical rounding operation, for example, the process parameters have to be set such that the peeling forces are in the range from 0.1 N up to about 0.15 N.

The fixing periods indicated above vary, of course, in dependence upon the process parameters and apply in particular for the special case in which concentrated formic acid is used as solvent at a temperature of about 20°C, with the filaments being made of polyamide (PA6.12) and having a diameter ranging from about 0.076 mm up to 0.126 mm.

By the processes of winding, braiding or stranding the filaments, the individual filaments are brought in close relative contact. The tensile force acting on the filament composite produces a resultant force in the direction of the center 24 of the bristle 1, 6, 12. Due to the action of the chemical agents or solvents, the surface of the filaments 2, 3, 4; 7, 8, 9, 10; 13, 14, 15 is partially dissolved, producing a doughy state. In the process, the secondary valency forces effecting the confinement of the substances are diminished by the solvent, without practically attacking or destroying the covalent bonds. This state enables the diffusing of molecular segments over the interfaces into the neighboring component. In this process, the penetration depth of the molecular chains is dependent on the degree of partial dissolution and the amount of tensile stress, and it exerts an effect on the bond strength of the overall system. The bond in turn is based on the secondary valency forces of the atoms of neighboring molecular chains which unfold fully again after the solvent is washed out subsequently.

For the purposes of this application, chemical welding is understood to mean a joining of the filaments by partial dissolving of the surface of the filaments by means of a chemical solvent. By contrast, in a thermal welding process the surface of the filaments is softened by the action of heat. Where filaments are joined together by adhesive bonding, an additional substance is permanently applied to the filament surface to join the filaments together.

The described bristles 1, 6, 12 of FIGS. 1a to 1c, 2a and 2b as well as 3a and 3b are intended for use in toothbrushes, particularly for use in electric toothbrushes. The described bristles 1, 6, 12 may be used particularly advantageously in the inner field of a round-head tooth brush.

## Patent Claims

1. A bristle (1, 6, 12) for a toothbrush, in particular for an electric toothbrush, which is made of plastic and includes several filaments (2, 3, 4; 7, 8, 9, 10; 13, 14, 15) joined together, characterized in that the filaments (2, 3, 4; 7, 8, 9, 10; 13, 14, 15) are wound or braided and chemically welded together as a result of the action of chemical agents.

2. The bristle (1, 6, 12) as claimed in patent claim 1, characterized in that the free end (17) of the bristle (12) has a fanned arrangement (18).

3. The bristle (1, 6, 12) as claimed in any one of the patents claims 1 or 2, characterized in that between two and eight filaments are provided per bristle, in particular three or four filaments per bristle.

4. The bristle (6) as claimed in any one of the patents claims 1 to 3, characterized in that the filaments (7 or 8, 9, 10) of the bristle (6) have different diameters.

5. The bristle (1, 6, 12) as claimed in any one of the preceding patent claims, characterized in that the diameter of the filaments (2, 3, 4; 7, 8, 9, 10; 13, 14, 15) lies between 0.0508 mm (2 mils) and 0.254 mm (10 mils), approximately, in particular between 0.0762 mm (3 mils) and 0.127 mm (5 mils), approximately.

6. The bristle (6) as claimed in any one of the patents claims 1 to 5, characterized in that one approximately central filament (7) is provided with greater rigidity and is surrounded by filaments (8, 9, 10) of less rigidity.

7. The bristle (1, 6, 12) as claimed in any one of the patents claims 1 to 6, **characterized in that** the winding or braiding of the bristle (1, 6, 12) follows a periodic pattern (5, 11, 16).

5 8. The bristle (1, 6, 12) as claimed in patent claim 7, **characterized in that** the repeat value (5, 11, 16) is between 0.5 mm and 5.0 mm, approximately, in particular between 1.0 mm and 3.0 mm, approximately.

10 9. The bristle (1, 6, 12) as claimed in any one of the patents claims 1 to 8, **characterized in that** the filaments (2, 3, 4; 7, 8, 9, 10; 13, 14, 15) are made of polyamide, polyester and/or polypropylene.

15 10. The bristle as claimed in any one of the preceding claims, **characterized by** a tear-growth resistance of the fanning (18) or a peeling force of the filaments (13, 14, 15) of between 0.1 N and up to 0.15 N, preferably of 0.125 N.

20 11. The bristle as claimed in any one of the preceding claims, **characterized in that** amounts of 10% up to 50%, preferably 20% to 35%, of the cross-sectional area of the filaments (2, 3, 4; 7, 8, 9, 10; 13, 14, 15) are partially dissolved as a result of the action of the chemical agents.

25 12. The bristle as claimed in any one of the preceding claims, **characterized in that** in cases in which filaments of a crystalline or part-crystalline material are employed, an outer envelope (22) of the bristle (1, 6, 12) has an essentially amorphous structure, and an inner core (23) has an essentially crystalline structure.

30 13. The bristle as claimed in claim 12, **characterized in that** a center (24) of the inner core (23) has an amorphous structure.

14. The bristle as claimed in any one of the claims 12 to 13, **characterized in that** amounts of about 10% up to 50%, in particular 20% up to 30% of the area of cross-section of the bristle (1, 6, 12) possess an amorphous structure.

5 15. A method of manufacturing a bristle as claimed in any one of the patent claims 1 to 14, **characterized in that** the filaments (2, 3, 4; 7, 8, 9, 10; 13, 14, 15) are wound or braided essentially without torsional stress and are chemically welded together by the action of a solvent.

10 16. The method as claimed in patent claim 15, **characterized in that** the filaments (2, 3, 4; 7, 8, 9, 10; 13, 14, 15) are wetted with a solvent for a period of between 5 s and 50 s, approximately, preferably for a period of between 5 s and 15 s or 20 s and 30 s, approximately, depending on the surface  
15 coating of the filaments.

17. The method as claimed in any one of the patent claims 15 or 16, **characterized in that** phenol, M-cresol and/or formic acid are used as solvents.

20 18. The method as claimed in any one of the patent claims 15 to 17, **characterized in that** a fanned arrangement (18) of the free end (17) of the bristle (12) is obtained by a mechanical operation.

25 19. The method as claimed in any one of the patent claims 15 to 18, **characterized in that** during the chemical welding process the wound and/or braided filaments (1, 6, 12) are exposed to a tensile stress of between 6 MPa and up to 20 MPa, approximately, preferably 13 MPa.

30 20. The use of the bristle (1, 6, 12) as claimed in any one of the preceding patent claims in the inner field of a preferably electrically powered round-head toothbrush.



# Abstract of the Disclosure

The invention is directed to a bristle (12) for a toothbrush, in particular for an electric toothbrush, which is made of plastic and includes several filaments (13, 14, 15) joined together. The filaments (13, 14, 15) are wound or braided and joined together as a result of the action of chemical agents. This results in a firm bond between the filaments (13, 14, 15), and any cavities between the filaments (13, 14, 15) are reliably avoided. Overall, a toothbrush results which, in addition to having a high cleaning effect, offers bacteria or other germs no possibility of infiltration.

(FIG. 4)

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